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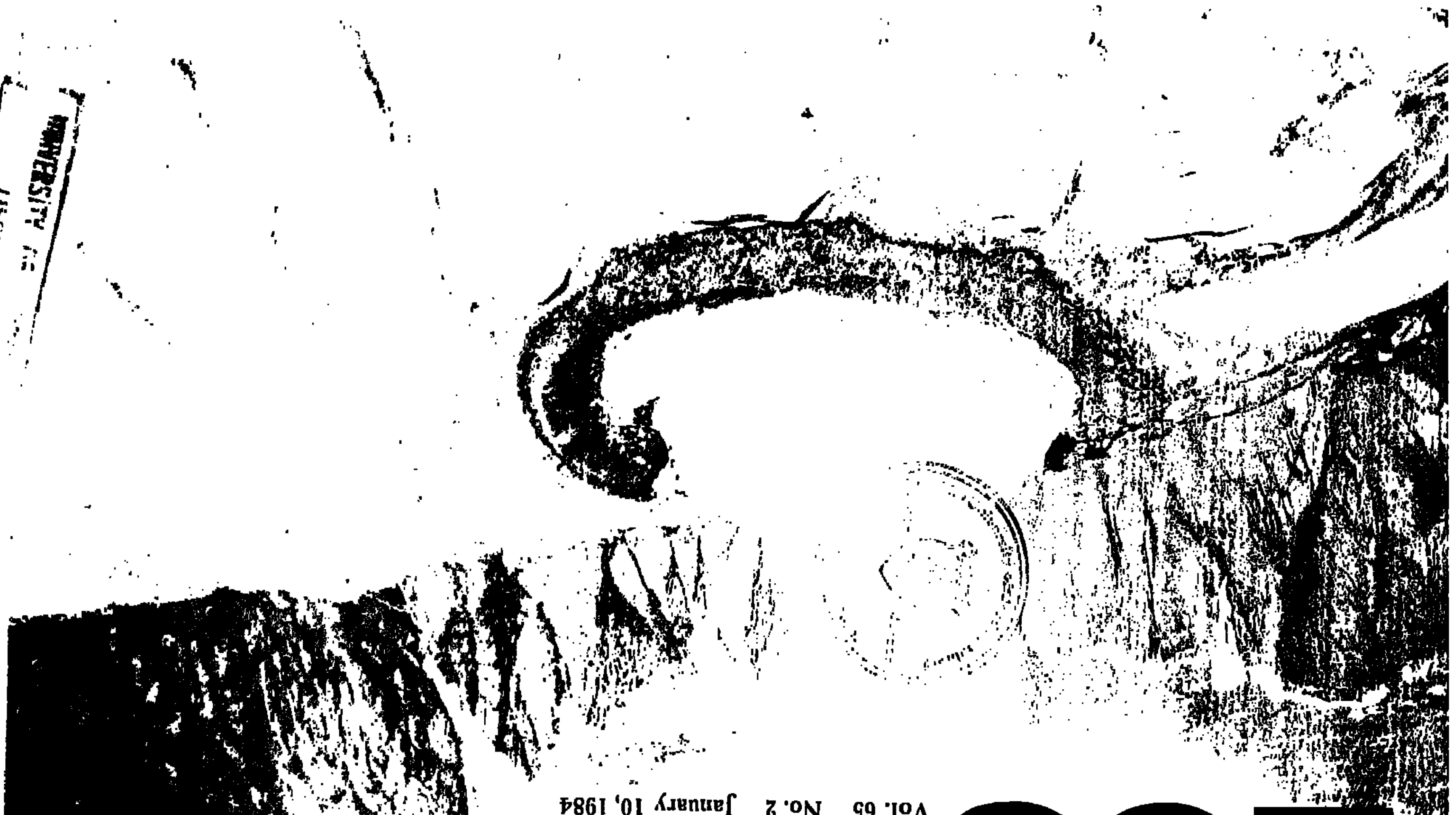

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In Congress

NOAA Budget Set

In late November, President Ronald Reagan signed into law the National Oceanic and Atmospheric Administration (NOAA) budget, which is part of the appropriations bill for the Departments of Commerce, Justice, State, the Judiciary, and related agencies; at the same time, he also signed into law an amendment attached to that bill that prohibits the sale of the weather satellites (*Eos*, May 17, 1983, p. 377, and March 22, 1983, p. 113). Commercialization of the land remote sensing satellite system is still being considered, however.

As a result of the conference between the House of Representatives and the Senate appropriations committees, the appropriation for NOAA totals $1020.6 million, with a program level of $1073.1 million. The appropriation is the money that comes from the federal treasury; the program level represents all of the funds—including treasury funds, transfers, residuals, etc.—actually available for the program. Strictly in terms of dollars, the total fiscal 1984 NOAA appropriation is almost level with the fiscal 1983 appropriation of $1000.9 million. In fiscal 1984, NOAA's research core, called Operations, Research, and Facilities (ORF), receives an appropriation of $988.2 million, with a program level of $1014.8 million.

Table 1 compares the 1983 base, the Reagan budget proposal, and the final conference program levels for ORF. The 1983 base, which is a conservative estimate of spending, is lower than the actual 1983 expenditures, which were being calculated as *Eos* went to press.

The satellite and environmental data and information services activity gets the biggest dollar increase, much of which goes to maintaining various satellite systems. Included in the increase for the satellite systems subactivity is an additional $20.4 million for the launch of Landsat D'; President Reagan added these funds to his initial budget request. Funding for data and information services, however, drops to a program level of $22.8 million.

Most of the increase for atmospheric programs, which accounts for more than one-third of ORF funds, goes to the public warning and forecast services subactivity. Within this subactivity, $10 million is slated for NEXRAD, the next generation weather radar system to improve severe weather forecasting (*Eos*, June 14, 1983, p. 411). Like the funds for the Landsat D' launch, this $10 million was amended to the president's initial request.

In the ocean and coastal programs activity, Congress restored funds to the Sea Grant program, which President Reagan had proposed to eliminate. Coastal zone management, which was included in ocean and coastal programs in the Reagan budget request, was removed entirely from ORF by Congress and established as a separate account.

The appropriations bill for Commerce, Justice, State, the Judiciary, and related agencies (H.R. 3222) was signed into law (P.L. 98–166) on November 28 by President Reagan. The bill included a rider, attached on the bill's way through Congress, that prohibited the federal government from spending money to solicit bids to carry out the proposed sale of the meteorological satellites. When the bill reached his desk, Reagan had the option of rejecting the budgets for all of those agencies or signing the bill. He opted to sign. This blocks only the sale of the weather satellites; plans to sell the land remote sensing satellite system are still under way by the Source Evaluation Board on Civil Space Remote Sensing.—*BTR*

TABLE 1. NOAA Operations, Research, and Facilities Fiscal 1984 Budget, Program Level, in Thousands of Dollars

Activity	1983 Base[1]	Reagan FY84 Proposal[2]	Final Conference FY84[3]
Ocean and Coastal Programs			
Nonliving marine resources	3,032	1,761	3,761
Ocean research	35,434	23,452	39,181
Ocean services	15,764	13,237	15,271
Sea Grant	35,000	0	36,500
Coastal zone management	14,226	6,056	7,706[4]
Mapping, charting, & geodesy	45,289	72,619	46,089
Subtotal	**148,745**	**117,125**	**148,508**
Marine Fishery Resource Programs	**146,491**	**92,444**	**147,318**
Atmospheric Programs			
Public warning & forecast services	272,221	264,936	311,100
Atmospheric & hydrologic research	49,042	44,561	51,856
Subtotal	**321,263**	**309,497**	**362,956**
Satellite & Environmental Data & Information Services			
Satellite services	66,617	73,279	71,479
Satellite systems	106,500	117,361	157,761
Data & information services	25,639	22,315	22,783
Subtotal	**198,756**	**212,955**	**252,023**
Program Support	**115,813**	**95,353**	**111,678**
Total, ORF	**931,068**	**827,372**	**1,014,777**

Source: NOAA. Numbers may not total because of rounding.
[1]The 1983 base is an estimate of 1983 spending. Actual expenditures are higher.
[2]See *Eos*, February 15, 1983, p. 65.
[3]Reflects congressional deliberations (see *Eos*, September 13, 1983, p. 548). The conference was completed October 31 and final approval was granted on November 16. The appropriations bill (H.R. 3222) was signed into law (P.L. 98–166) on November 28.
[4]Although the Reagan proposal includes Coastal Zone Management (CZM) in Ocean and Coastal Programs, Congress moved it into a separate account outside of ORF. The final conference ORF total does not include CZM.

December Streamflow

The high streamflows of recent months in the West eased somewhat during December, but streamflows increased in much of the eastern United States, setting many record or near record high flows in several states, according to the monthly check on national water resources conditions by the U.S. Geological Survey (USGS).

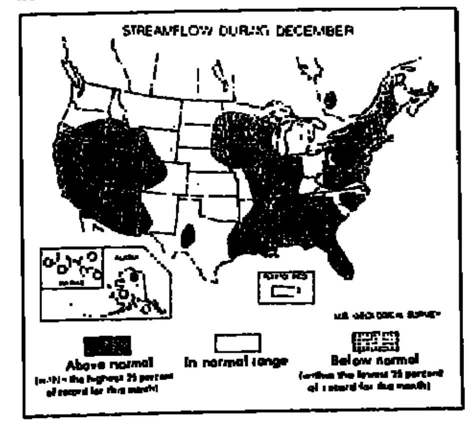
USGS hydrologists said that record or near record high average streamflows for the month were set at 36 stations in 24 states from Georgia to Alaska. In contrast to the many historic high flows, reports of low streamflows were isolated and unusual, with most low flows occurring between the Mississippi River and the Rocky Mountains and in the Pacific Northwest (see map, courtesy USGS).

Of the 173 key USGS gaging stations surveyed across the country, 127 (73%) reported streamflows well above average (in the highest 25% of record), 33 stations (19%) reported flows in the normal range, while only 13 stations (7%) were in the lowest 25% of record.

Reflecting the widespread and extremely wet conditions nationwide during December, the combined flow of the nation's three major rivers—the Mississippi, St. Lawrence, and Columbia—was 3937 billion liters per day (bld) (866 billion gallons per day), 68% above the long-term December average, and 64% greater than the combined flow in November. These three major rivers provide a useful check on the nation's water resources because they drain more than half of the coterminous United States.

Groundwater levels across the nation tended to be higher in December, largely in response to above-normal precipitation. Wells reached record high levels for December in New York, Connecticut, Maryland, Maine, and Nevada. Indicating the variability in the response of groundwater levels to local conditions, single wells in Maine and Nevada also set record low levels for the month.

Individual flows of the so-called "Big Five" rivers for December were as follows: the Mississippi River at Vicksburg, Miss., 2882 bld, 107% above average and 137% more than the flow in November; the St. Lawrence River near Massena, N. Y., 777 bld, a decline of 2% from November, but 11% above the monthly average; the Columbia River at The Dalles, Ore., 277 bld, a decline of 28% from November, but 9% above the long-term December average; the Ohio River at Louisville, Ky., 532 bld, or 40% more than the long-term monthly average, and an increase in mean flow of 77% from the previous month; and the Missouri River at Hermann, Mo., 245 bld, 107% above the usual December readings, but down 19% from the November flow.



Geophysicists

Jeffrey Alt, a student at the University of Miami's Rosenstiel School of Marine and Atmospheric Science, recently was awarded the Koczy Fellowship, given to a doctoral student at the school who has displayed "exemplary scholastic and research ability." His disseration focuses on the mechanisms of submarine hydrothermal systems and on the role that hydrothermal alteration of the oceanic crust plays in regulating seawater composition.

Kimberlee Miskell, a student in marine geology and geophysics at the Rosenstiel School, has been awarded the 1983 Dean's Prize for the year's outstanding master's thesis. Her thesis is entitled "Accumulation of Opaline Silica in Deep Sea Sediments from the Mid-Cretaceous to the Miocene: a Paleocirculation Indicator."

Also at the Rosenstiel School, ***Alina Szmant-Froelich*** has been appointed a member of the faculty. Next spring she will continue her studies of coral reef energetics and nutrient dynamics at the Hydrolab in the U.S. Virgin Islands.

Peter Angus-Leppan, head of the school of surveying at the University of New South Wales in Sydney, Australia, has been awarded a senior scientist grant by the U.S. National Academy of Sciences' National Research Council. The grant will enable him to undertake geodesy research with the U.S. National Geodetic Survey. Angus-Leppan also was recently elected president of the International Association of Geodesy for 1983–1987.

Anton L. Inderbitzen is the new associate chief scientist of the Polar Science Division, Division of Polar Programs, in the National Science Foundation.

Recent Ph.D.'s

Eos periodically lists information on recently accepted doctoral dissertations in the disciplines of geophysics. Faculty members are invited to submit the following information, on institution letterhead, above the signature of the faculty advisor or department chairman:

(1) the dissertation title,
(2) author's name,
(3) name of the degree-granting department and institution,
(4) month and year degree was awarded.

If possible include the current address and telephone number of the degree recipient (this information will not be published).

Many dissertations, including those with order numbers, are available from University Microfilms International, Dissertation Copies, P.O. Box 1764, Ann Arbor, MI 48106.

Applications of Hydrologic Modeling to Water Resource Assessment (Connecticut), Michael J. Brown, Harvard Univ., 1983 (GAX83–22310).

Biogeochemistry of Manganese and Iron in the Pacific Ocean, William M. Landing, Chemistry Dept., Univ. of California at Santa Cruz, June 1983.

Causation and Variability of the Northern Winter Quasi-Stationary Planetary Waves, David A. Jacqmin, Harvard Univ., 1983 (GAX83–22377).

Clear Atmospheric Effects on Insolation Illustrated by Broad-Band Radiometer Measurements (Washington, Mt. St. Helens), Daniel W. Spencer, State Univ. of New York, Albany, 1983 (GAX83–22620).

Depositional and Diagenetic Environments of Carbonate-Siliciclastic Rocks of the Glen Dean Formation (Upper Mississippian), Illinois Basin, U.S.A., Sadat Feiznia, Univ. of Illinois, Urbana-Champaign, 1983 (GAX83–24547).

Effect of Asymmetric Ekman Dissipation on Finite-Amplitude Baroclinic Disturbance, Shih-Hung Chou, Dept. of Atmospheric Science, State Univ. of New York at Albany, December 1983.

Generation and Characterization of Particulate Aerosols From Virgin Carbon Fibers and Composites, Richard J. Chang, Univ. of Arkansas, 1983 (GAX83–22962).

Interpretation of the Aeromagnetic Data Covering Portion of the Damara Orogenic Belt, With Special Reference to the Occurrence of Uraniferous Granite, Branko Corner, Univ. of Witwatersrand (South Africa), 1983.

Migration of Reflection Seismic Data in Angle-Midpoint Coordinates, Richard A. Ottolini, Stanford Univ., 1983 (GAX83–20760).

Moisture and Heat Transport, and Ocean Cooling Along the Track of a Moving Storm, Sami F. Al-Fahed, Catholic Univ. of America, 1983 (GAX83–24404).

Numerical Investigation of the Formation of Secondary Vortices in Laboratory-Simulated Tornadoes, Robert L. Walko, Univ. of Arizona, 1983 (GAX83–24466).

Paleomagnetism, Rock Magnetism and Diagenesis in Hemipelagic Sediments From the NE Pacific Ocean and the Gulf of California, Robert Karlin, Dept. of Geophysics, Oregon State Univ., November 1983.

Temperature and Axial Strain Rate Effects on Micromechanical Behavior in Triaxially Compressed Marbles, Joseph K. Schroth, Univ. of Illinois, Urbana-Champaign, 1983 (GAX83–24638).

Coastal Mining

The Exclusive Economic Zone (EEZ) declared by President Reagan in March 1983 has met with a mixed response from those who would benefit from a guaranteed, 200-nautical-mile (370-km) protected underwater mining zone off the coasts of the United States and its possessions. On the one hand, the U.S. Department of the Interior is looking ahead and has been very successful in safeguarding important natural resources that will be needed in the coming decades. On the other hand, the mining industry is faced with a depressed metals and mining market.

A report of the Exclusive Economic Zone Symposium held in November 1983 by the U.S. Geological Survey, the Mineral Management Service, and the Bureau of Mines described the mixed response as: "... The Department of Interior ... raring to go into promotion of deep-seal mining but industrial consortia being very pessimistic about the program, at least for the next 30 or so years." (*Chemical & Engineering News*, February 5, 1983).

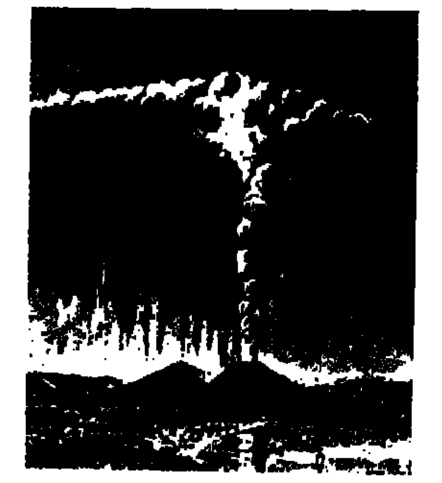
The circumstances are not too different from those surrounding U.S.-sponsored ocean margin drilling programs. The government would like to spend the required effort now to lay the groundwork for future decades. The petroleum industry sees at least 1 or 2 decades of relatively cheap continental petroleum sources being available and would like to delay the huge costs of continental margin exploration.

Right now there are few if any confirmed economic mineral deposits within the EEZ. There are copper ores that are not being mined due to the depressed international market. Indeed, copper prices have not risen in almost 2 decades. The new extended zones will experience little actual mining activity until they are explored and evaluated. A serious factor in their development will be environmental protection. Lacking the costs of satisfactory environmental constraints, foreign-produced metals are proving to be much cheaper in the United States than domestically produced metals. Exploration, evaluation, and a working minerals policy will be key issues in the development future of EEZ ore deposits, but costly research and exploration in high-risk zones is not a high priority for U.S. mining companies because of the economic realities of world markets.

The EEZ legislation is a United States initiative not unrelated to the decade-long efforts to produce the Law of the Sea. The most important deposits originally envisioned for the Law of the Sea exploitation were for the most part manganese nodules. The mining of nodules is yet to be realized on a significant scale, and it may be some time before they can be dredged from the ocean floor economically. The more recent discovery of polymetallic sulfides associated with underwater hot springs has resulted in heightened efforts to protect national resources, and to extend potential mining zones. Whatever U.S. government plans may call for, however, ores requiring expensive mining procedures will not be competitive for the present. It is much more economical to import ores, metals, and indeed, finished products in the current market. The metals market in the United States is characterized, at least in the short term, by overcapacity.

Aside from metals, phosphorite deposits located within the EEZ may turn out to be the first exploited. A large percentage of mineral phosphates are used to make fertilizers, and unlike metals futures, the world demand for phosphates is expected to increase by 70% or more by the end of this century. Thus, there is a good chance that phosphate mining will move offshore by the end of the century. The United States, within the new zones, now has control of sizable deposits.—*PMB*

The VGP News



Editor: Bruce Doe, 11721 Bay River Court, Reston, VA 22091 (telephone 703-860-1170, after 5:30 p.m.)

A Relation Among Geomagnetic Reversals, Seafloor Spreading Rate, Paleoclimate, and Black Shales

Eric R. Force

The Mesozoic-Cenozoic histories of reversals in the earth's magnetic field and of periods of widespread anoxia in the ocean basins show a remarkable correlation (Figure 1): periods of black-shale deposition ("anoxic events") occur during lengthy periods without magnetic reversals ("quiet" periods). My assembly of published work indicates a remote connection between quiet periods and anoxic events and suggests its form: Magnetic quiet periods coincide with fast seafloor spreading. During these periods, buoyant spreading ridges displace seawater onto broad shelves, thus decreasing earth's albedo and causing global warming. Temperature gradients, and thus density gradients, from pole to equator decrease in surface waters, and the deep-ocean currents of oxygenated polar waters wane. Oxygen minimum zones intensify and widen; anoxic conditions throughout entire basins are indicated by black shales deposited in the deep sea. These relations thus suggest that the earth's interior processes and its climate are related and their status recorded by both magnetic polarity and anoxic event chronologies of the earth. A test of the model for the Paleozoic is proposed and some implications for mineral resources noted.

Sheridan et al. [1982] noted an empirical link, based on both the Jurassic and Cretaceous quiet zones, between fast seafloor spreading and stable magnetic polarity. They suggested that erupting heat plumes couple activity of the outer core and lower mantle. The relationship between magnetic polarity and spreading rate is seen at several spreading centers (Figure 1).

The link between fast spreading and transgression is well established [*Hays and Pitman*, 1973]. Because newly generated oceanic crust cools and subsides as a function of time regardless of spreading rate, fast-spreading centers have a broad cross section (Figure 2). An increase in spreading rate thus displaces seawater onto continental shelves and into epicontinental seaways. Cretaceous high sea levels observed in sections on cratons correspond to times of fast spreading [*Hays and Pitman*, 1973; *Vail et al.*, 1977].

Calculations of the earth's albedo in the Cretaceous (with continents in their correct positions for the time) show that high sea levels and consequent larger oceans resulted in a significant albedo decrease [*Barron et al.*, 1980]. More solar energy was absorbed. However, estimates of the magnitude of warming are not yet possible because feedback factors such as cloudiness are poorly understood. Greater atmospheric CO_2 contents due to increased volcanism during times of fast spreading [*Berner et al.*, 1983] reinforced this effect. Warmer paleoclimates have long been observed from fossil assemblages and oxygen-isotope measurements (Figure 1) for roughly the Aptian to Campanian (mid-late Cretaceous) and the Middle to Late Jurassic [*Douglas and Savin*, 1975; *Frakes*, 1979; *Savin*, 1977; *Gordon*, 1974].

A decrease in the surface-temperature gradients from pole to equator is also observed by these authors from these time periods; i.e., the temperature increase near the pole was greater than that near the equator. These gradients are lower during warm periods because polar ice caps with high albedos retreat and because poleward transport of the latent heat of evaporated water increases [*Manabe and Wetherald*, 1980; *Kellogg*, 1979].

A link between low temperature gradients and ocean stagnation was proposed [*Schlanger and Jenkyns*, 1976; *Fischer and Arthur*, 1977] partly because of coincident timing of widespread black-shale deposition (anoxic events) and periods of equable climate. Compare the situation today with that in the Cretaceous: today's high temperature gradients (and some generation of saline waters by incongruent freezing) cause high density gradients in seawater and drive vigorous bottom currents from the poles. These currents today prevent significant ocean stratification; ocean-wide zones of strong oxygen-minima form only where bottom currents are weak e.g., the north Pacific [*Demaisson and Moore*, 1980]. In the Jurassic and Cretaceous, low temperature gradients must have resulted in weaker bottom currents (though probably not in weaker surface and atmospheric circulation [*Barron and Washington*, 1982]). Bottom waters may have been generated in sub-tropical evaporative basins [*Thierstein and Berger*, 1979]. Strong oxygen-minimum zones became widespread. Intersections of oxygen-minimum zones with ocean floors are the sites of black shales penetrated in Deep Sea Drilling Project (DSDP) holes and sections now on land (Figure 2); locally, black shales formed in silled basins also [*Thierstein and Berger*, 1979]. The timing of black-shale deposition is shown as anoxic periods on Figure 1.

Periods of widespread anoxia are of economic importance because the organic precursors of petroleum were preserved in sediments [*Arthur and Schlanger*, 1979]. These periods also saw formation or preservation of some metal deposits [*Cannon and Force*, 1983; *Force et al.*, 1983], due to strong solubility contrasts between anoxic and oxygenated water. For example, massive polymetallic sulfides that formed on ocean floors during anoxic periods have probably been selectively preserved (Figure 2).

Other authors have assembled some of the same links to form other models [e.g., *Keith*, 1982]. The models most similar to the one in this paper are in *Fischer* [1981] and *Sheridan* [1983].

Genetically related events should be similarly spaced in time, and this spacing has not been shown yet across the spectrum of linkages proposed here. Mesozoic changes of spreading rate are presently documented only over time periods of about 10–30 m.y., whereas anoxic periods and their associated sea level fluctuations (third-order fluctuations of *Vail et al.* [1977]) occupy 3–10 m.y. (Figure 1). Currently available spreading-rate histories for the Mesozoic are very crude, however. In order to see whether hidden changes in spreading rate could plausibly result in observed 3–10 m.y. fluctuations, I calculated "backward" to determine a spreading-rate increase which could result in a sea level rise of 100 m in 3 m.y. Present total length of ridges (58,750 km), cylindrical ocean basins, and present areas of oceans and of land areas 0–100 m in elevation were assumed. The increase required is about 2.1 cm per year half rate for all ridges, or about 12–70% of observed average spreading rates for ridges listed by *Hays and Pitman* [1973] for the Cretaceous magnetic quiet interval. This rate seems possible, and therefore changes in spreading rate might indeed cause 3–10 m.y. sea-level fluctuations. The question of regression rate was not addressed. *Schlanger et al.* [1981] record midplate seafloor volcanism and raised seafloors from the Cretaceous; these factors (and ridge proliferation) are probably related to spreading rate changes, and potentially lessen the magnitude of increased spreading rate needed to produce transgression.

With oriented DSDP cores, testing of this hypothesis by resolving the sequence of events within single core sections should be possible. Onset of anoxic bottom conditions should not precede magnetically quiet intervals (unless the model is backwards!).

If this hypothesis has genetic significance, it should hold regardless of when the specified conditions occurred. Periods of widespread anoxia have been proposed for the Paleozoic, from black shale sections on land alone because no intact ocean floor remains [e.g., *Leggett*, 1980]; these sections should not contain magnetic reversals in those portions showing carbon-isotope records of open-ocean anoxia. Numerous other tests of the model would see how well one factor predicts another: if results are positive, some of these tests could develop into mineral-exploration techniques (for example, a link between magnetic polarity and some sedimentary minerals).

Many of the linkages proposed here are matters of dispute or incomplete work, so errors in my depiction are likely. Nevertheless, the accord with observed features of earth history across the entire spectrum of linkages, and the similarity of the "signals" recorded by magnetic reversals and anoxic periods are indications that the general form of the hypothesis is correct. If so, a connection exists between processes in the earth's interior which produce its magnetic field and climatic response at its surface.

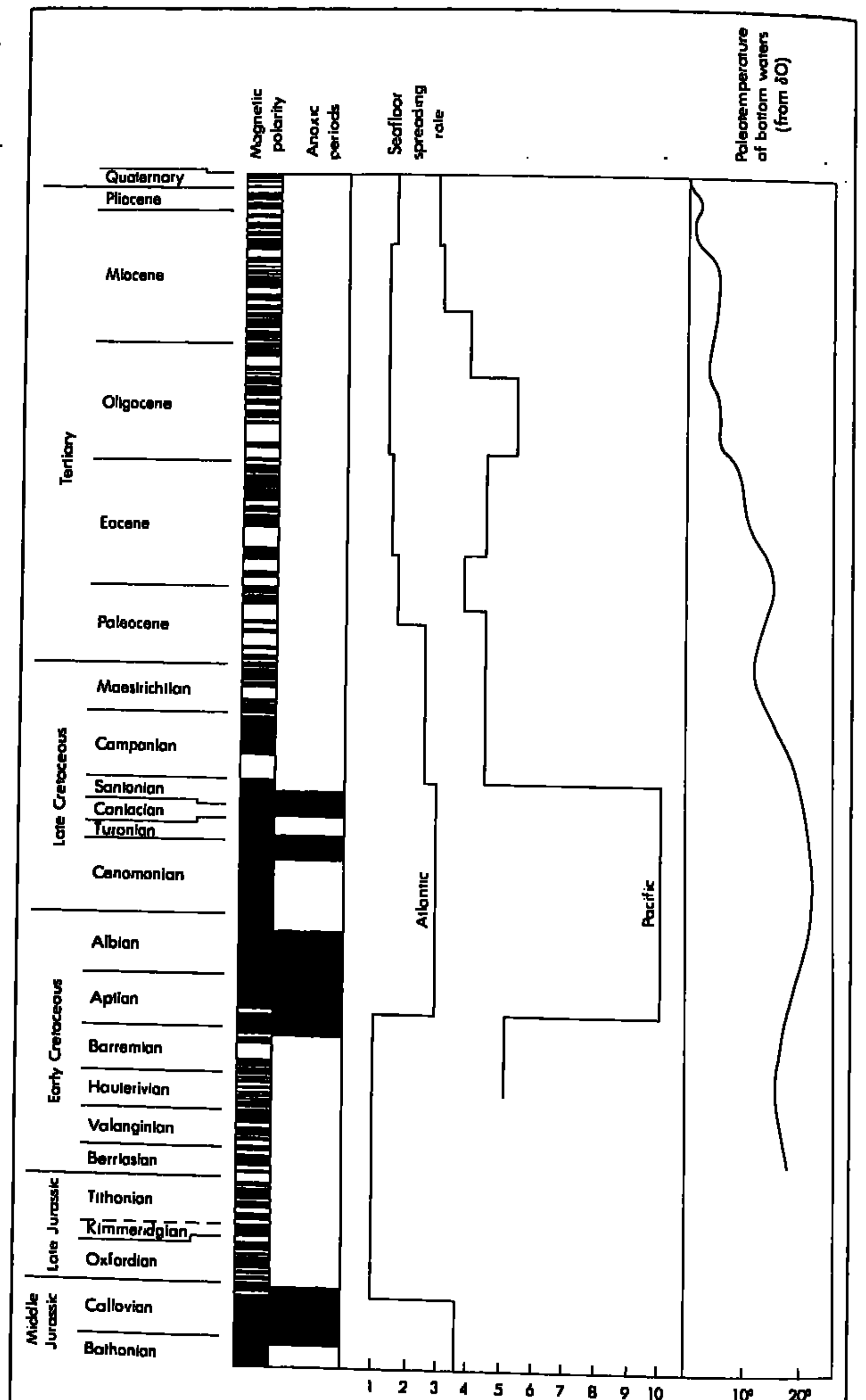


Fig. 1. Comparison of magnetic polarity time scale [*Larson et al.*, 1982] with periods of widespread anoxia [*Arthur*, 1979], average half-rates of sea floor spreading (simplified from *Larson and Pitman* [1972]; and *Sheridan et al.*, [1982]) and oxygen isotope-derived bottom paleotemperatures from the north Pacific [*Douglas and Savin*, 1975]. The presence of all the chronologies in a single data set (cores of the DSDP), minimizes systematic offsets, but detailed correlation is still a problem.

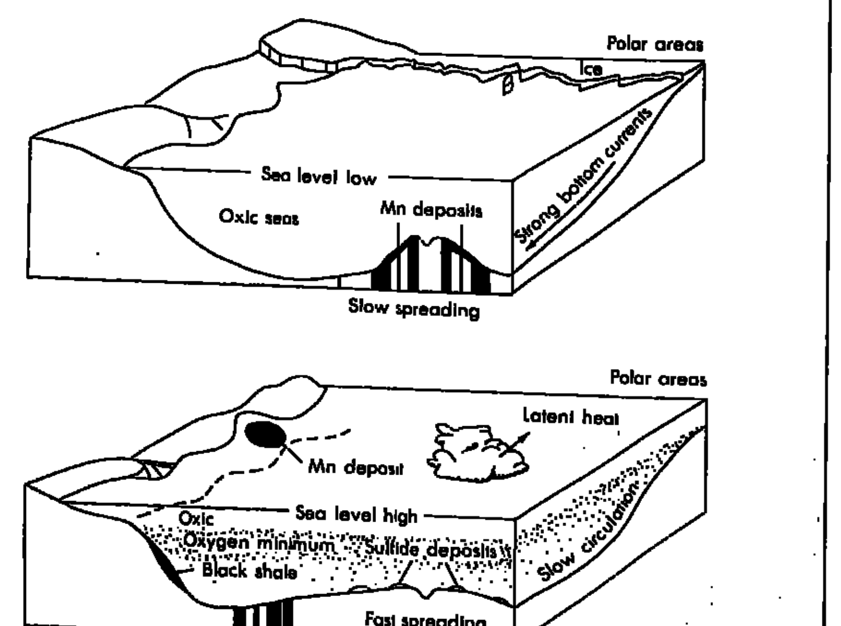


Fig. 2. Cartoon contrasting (*top*) state of rapid magnetic reversals, slow spreading, low sea level, cold high-gradient climate and oxic oceans (icehouse state of *Fischer* [1981]) and (*bottom*) state of magnetic quiet, fast spreading, high sea level, warm low-gradient climate and dysaerobic oceans (greenhouse state). Degree of oxygen depletion proportional to stippling; oxygen minimum zones would intersect only seamounts, plateaus, and basin margins in the deeper Pacific.

I am indebted to W. F. Cannon, R. P. Sheldon, Louis Nicolaysen and others for discussions on the form of linkages and to L. W. Snee and Lisa M. Pratt for help in formulating the Palezoic test. Suggestions by participants in the 1983 Penrose conference "Cretaceous Climates" are appreciated.

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Cover. Geological formation known as the Great Dike of Rhodesia extends from upper center to lower left in this photograph taken from space shuttle *Challenger* as it passed over Zimbabwe during the eighth shuttle mission, September 1983. Because of the shuttle's nighttime launch, the crew was able to photograph during daylight parts of Africa, the Amazon jungle, and the Australian desert that previous crews had seen only at night. (Photo courtesy of NASA.)

An Invitation

Would you like to be on the cover of *Eos*? If you have any illustrations with both aesthetic charm and scientific interest—photographs (preferably black and white) of geophysical phenomena, experimental results, or graphs—*Eos* would like to consider them for publication on the cover. Send the original illustration or 8 x 10 inch (20 x 25 cm) glossy photo with a short (50–200 words) explanation that can serve as a caption. You may also submit a more extensive news item or even a short article to accompany a proposed cover. Captions will be by-lined. If the material has been previously published, please supply a copyright release from the copyright owner. Send it to *Eos* Cover, AGU, 2000 Florida Avenue, N.W., Washington, DC 20009.

Meetings

Water in Silicate Melts

Water is one of the more important volatile species in magmas, both in terms of its abundance and its influence on the properties of a given magma. Many workers in the geological sciences have measured, modeled, and speculated on the interaction of water with silicate melts as a function of pressure. At the same time, glass and materials scientists have collected a considerable body of data on the effect of water on the properties of liquid and glassy silicates at 1 atmosphere (1.01325 x 10^5 N m^{-2}) and below. A special session on "Solubility and Transport Properties of Water in Silicate Melts" was held during the 1983 AGU Spring Meeting, May 30–June 3, in Baltimore. The session had three main objectives: (1) review the present data base and discuss the status of current models in order to identify areas where further work is needed; (2) introduce interested geologists to the large body of work being carried out in the glass and materials sciences; and (3) consider static properties, such as thermodynamic relations, structure of hydrous melts, and dynamic properties including diffusion and viscosity. This report summarizes the major topics discussed. More detailed information may be found in the published abstracts (*Eos*, May 3, 1983, pp. 338–343).

The session opened with two papers setting the geological perspective of water solubility in magmas. J. Eichelberger and H. Westrich discussed the observed water content and distribution in obsidian flows, where the average observed water content reflects the solubility of water in rhyolite liquid at near 1 atmosphere pressure. They considered the effect of degassing on water distribution within observed flows, and on the water content of ejected material during explosive eruption. J. Clemens reviewed measured and estimated contents of water for a variety of andesitic to granitic rocks. He found melt-water contents between 0.7 and 7 wt % water depending on the sample and source conditions (but with a general average value near 3 wt %), and he discussed the relative merits of methods for estimating water content. J. P. Coutures and G. Urbain presented a survey of solubility results obtained by glass and materials scientists for silicate glasses and liquids near 1 atmosphere. These water solubilities generally fall around 0.05–0.2 wt %, with some possible systematics as a function of composition. Discrepancies between different data sets, however, preclude any detailed correlations at present.

P. McMillan and J. Holloway summarized some water solubility measurements on synthetic and natural silicate melts at high pressures. Again, some systematic behavior with composition was noted, but the present data base is too limited to explore this fully. E. Stolper, L. Silver, and R. Aines summarized their recent infrared spectroscopic work on the speciation of water in hydrous silicate glasses and presented the results of new studies at high temperature. They found that both hydroxyl and molecular water species coexist to at least 550°C, supporting their dissolution model for water in molten silicates.

The next two papers concerned modeling of thermodynamic relations for hydrous melts. D. Eggler considered the dissolution reaction of water in diopside melt, and discussed Henrian, Henrian analogue ($a = x^4$), and non-Henrian expressions for its activity-composition relations. A. Boettcher presented experimentally determined melting curves in the systems $NaAlSi_3O_8$-H_2O-CO_2 and SiO_2-H_2O-CO_2. He compared and contrasted mixing relations in the fluids and silicate liquids for these two systems. These data suggested that CO_2 is soluble in SiO_2 liquids at high pressures (greater than or equal to 15 kbar) and high water contents. Discussion which followed this general topic emphasized that useful thermodynamic descriptions for such hydrous systems need not be simply correlated with structural changes in the melt.

Four papers examined the diffusion of water in hydrous glasses and melts and the effect of water on diffusion of other species. M. Tomozawa described the importance of water in the glass sciences and then presented the results of several studies of water diffusion in silicate glasses. One interesting result was the large observed dependency of the diffusion coefficient on the stress regime in nonhydrostatic experiments at relatively low pressure and temperature.

Two papers by K. Lapham and J. Karsten reviewed water diffusion studies in silicate melts and glasses and presented some results of their recent studies on diffusion of water in obsidian. Observed variations in the diffusion coefficient with temperature and composition were summarized and current models for the "water" diffusion mechanism were discussed. Lapham noted no pressure dependence of the diffusion coefficient in her obsidian study, in contrast to that observed by M. Tomozawa. This difference may be partly due to the higher pressures and temperatures involved in the obsidian runs and perhaps the hydrostatic nature of these latter experiments.

T. M. Harrison and E. B. Watson discussed the effect of water content on the diffusion of zirconium in granitic melts. They found a large increase in diffusivity and solubility at higher water contents and discussed the effect of this on zircon dissolution kinetics in hydrous granitic magmas.

The afternoon poster session included a number of presentations directly related to the discussions in the morning.

From informal discussions before, during, and after the meeting, we feel that the following general conclusions may be drawn. First, there are relatively few published estimates for water contents of primary igneous magmas, and more solubility data are necessary for synthetic and natural compositions at both high and low pressures. Likewise, diffusion data as a function of pressure, temperature, and composition are scant. Evidently more experiments are needed. Second, empirical modeling of thermodynamic and dynamic properties is a useful and necessary field, especially for those interested mainly in calculation of the effect of water on bulk properties. At the same time, mechanistic studies at the molecular level will lead to a better understanding of water-melt interactions at the microscopic level. More spectroscopic studies are needed on hydrous glasses, and especially on hydrous melts at pressure and temperature. We feel that both empirical modeling and structural studies are worthwhile and should be pursued with as much interplay between the two approaches as possible.

This meeting report was prepared by Paul McMillan, *who is with the Department of Chemistry, Arizona State University, Tempe, AZ 85287 and* Edward Stolper, *who is with the Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91109.*

Books

Geophysics in the Affairs of Man: A Personalized History of Exploration Geophysics and its Allied Sciences of Seismology and Oceanography

G. C. Bates, T. F. Gaskell, and R. B. Rice, Pergamon, Oxford, xx + 492 pp., 1982, $25.

Reviewed by Carl Kisslinger

This book traces the developments of the applications of the geophysical sciences to a variety of societal needs from misty beginnings to now, with emphasis on the "golden age," the early 1920's through the 1960's. The phrase "applied geophysics" is so often taken as synonymous with "geophysical exploration" that the broader viewpoint of this work is especially welcome. The authors certainly devoted much of their treatment to exploration geophysics, as is appropriate in view of the large commitment of human and financial resources to this endeavor and the practical importance of the results. However, they have also included interesting sketches of military applications of geophysical techniques and the important technological advances that have come from these, as well as much material on ocean science. Atmospheric and space science receives less detailed coverage.

The opening chapter, historical background to the developments of the 20th century, is brief, incomplete, and uneven in its coverage. An adequate treatment could well have doubled the size of the book, but some landmark developments that I looked for are missing. The heart of the book is the decade-by-decade story of each of the major themes (exploration, ocean science, global seismology) from the end of World War I through the 1960's. The story is told in terms of the personalities who built the subjects and the events that shaped their progress. It was fun to read this review and interpretation of one's teachers and friends. This is a humanized history of the grand projects that have moved geophysics ahead, the key technical developments along the way and the interplay of the creative minds responsible for progress.

The origins of seismic exploration for oil are explored, with emphasis on developments in the United States but with a fair treatment of European contributions. Gravity and magnetic methods are treated in less detail. The parallel growth of earthquake seismology and oceanography in the 1930's is presented in terms of the leaders who emerged and the institutions that nurtured the efforts.

The enormous impact of World War II on technical and theoretical developments important to geophysics follows. The progress in all areas in the postwar period is highlighted by the story of Project Vela-Uniform, the search for methods to monitor underground nuclear tests that jerked seismology into the modern era within a few years, beginning in 1959. The continuation of this effort to the present is a theme through the rest of the book. Progress and the new leadership that emerged in the 1970's and 1980's are not treated in any detail. The commercial aspects of exploration geophysics, a big business indeed, are also explored in a personalized way through the stories of a number of the companies, large and small.

The tale rambles a bit along the way and the authors get immersed in great detail in places where they are talking about topics with which they have been closely associated. As a reader who cannot ignore a footnote, I found the flow of the text interrupted continuously by the need to drop to the bottom of the page for the ancillary information offered. I was amused by the penchant for military titles used throughout (Rear Admiral Lloyd Berkner, USNR; Lieutenant "Jimmy" Carter, USN (Retired)).

I liked very much the personal evaluations by a number of well-known geophysicists of their own achievements and experiences. The book closes with this section, which should help remind today's students that the advancement of science, including triumphs and blunders, results from the efforts of people very much like themselves.

The authors have some strong prejudices that come through clearly in places. They don't like "environmentalists" and they take a dim view of a variety of national social programs of the recent past, including affirmative action in its various forms. I think that the kind of sarcastic assault on the environmentalist movement in the first part of chapter 7 has an effect similar to that of James Watt: The true believers perceive the need to circle the wagons more closely and dig in deeper. The authors do mention some of the outstanding women and minority-group members who have been leaders in the fields covered, but the fact remains that the number of such people is very small. I think that as a history of applied geophysics, the book would have been better without these elements, but here my own prejudices are showing clearly.

The book is a useful source of background on people and events that stimulated the growth of important parts of the geophysical sciences. It is especially important because it reminds us of the long-term effects on whole areas of human endeavor of isolated and apparently unrelated events.

Carl Kisslinger is with the Cooperative Institute for Research in the Environmental Sciences at the University of Colorado, Boulder, CO 80309.

New Publications

Items listed in New Publications can be ordered directly from the publisher; they are not available through AGU.

Air-Sea Exchange of Gases and Particles, P. S. Liss and W. G. N. Slinn (Eds.), D. Riedel, Boston, xiii + 561 pp., 1983, $69.50.

Changing Climate: Report of the Carbon Dioxide Assessment Committee, Board on Atmospheric Sciences and Climate, Commission on Physical Sciences, Mathematics, and Resources, National Research Council, National Academy Press, Washington, D. C., 1983, $29.95.

Deformation Measurements, I. Joo and A. Detrekoi (Eds.), Akademiai Koado, Budapest, xxii + 900 pp., 1983, $59.

Earthquakes, Tides, Unidentifed Sounds, and Related Phenomena: A Catalog of Geophysical Anomalies, Compiled by W. R. Corliss, The Source Book Project, Glen Arm, Md., 1983, $12.95.

Earthquakes, Volcanoes, and Tsunamis: An Anatomy of Hazards, K. V. Steinbrugge (Ed.), Skandia Corp., xv + 392 pp., 1982, $35.

Eddies in Marine Science, A. R. Robinson (Ed.), Springer-Verlag, New York, xxv + 609 pp., 1983, $45.

Equilibria, Nonequilibria, and Natural Waters, 2 vols., R. M. Pytkowicz (Ed.), John Wiley, New York; vol. 1, xv + 351 pp.; vol. 2, xv + 353 pp.; 1983, $49.95 each.

Groundwater Bibliography, F. van der Leeden, Geraghty & Miller, Syosset, New York, viii + 400 pp., 1983, $16.

Hydraulic Fracturing and Geothermal Energy, S. Nemat-Nasser, H. Abe, S. Hirakawa (Eds.), Martinus Nijhoff, Boston, xi + 528 pp., 1983, $78.50.

Ice Core Samples from Greenland and Antarctica, Ice Core Storage Facility and Information Exchange, SUNY Buffalo, New York, 49 pp.

Dam Safety Research Coordination Conference, Research Subcommittee of Interagency Committee on Dam Safety, Washington, D. C., 1983.

The International Field Year for the Great Lakes, E. J. Aubert and T. L. Richards (Eds.), National Oceanic and Atmospheric Administration, Ann Arbor, xi + 410 pp., 1983.

It Began with a Stone: A History of Geology From the Stone Age to the Age of Plate Tectonics, H. Faul and C. Faul (Eds.), John Wiley, New York, xvii + 270 pp., 1983, $38.95.

Kinetics and Equilibrium in Mineral Reactions, S. K. Saxena (Ed.), Springer-Verlag, New York, x + 273 pp., 1983, $39.80.

The Major Biogeochemical Cycles and Their Interactions, B. Bolin and R. B. Cook (Eds.), John Wiley, New York, xxi + 532 pp., 1983, $74.95.

*Man, A Geomorphological Agent*An Introduction to Anthropic Geomorphology, D. Ashboren (Ed.), D. Riedel, Boston, xii + 165 pp., 1983, $45.50.

Metal Pollution in the Aquatic Environment, U. Forstner and G. T. W. Witman (Eds.), Springer-Verlag, New York, 1983, $29.

The Phanerozoic Geology of the World, M. Moullade and A. E. M. Nairn (Eds.), Elsevier, New York, x + 450 pp., 1983, $12.75.

The Physics and Chemistry of Color: The Fifteen Causes of Color, John Wiley, New York, xx + 454 pp., 1983, $43.95.

Practical Sedimentology, D. W. Lewis, Hutchinson Ross, Stroudsburg, Pa., ix + 229 pp., 1984.

Principles of Aquatic Chemistry, F. M. M. Morel, John Wiley, New York, ix + 446 pp., 1983, $49.95.

Social Science Research and Climate Change: An Interdisciplinary Appraisal, R. S. Chen, E. Roulding, S. H. Schneider (Eds.), D. Riedel, Boston, viii + 255 pp., 1983, $43.50.

Solar-Terrestrial Physics: Principles and Theoretical Foundations, R. L. Carovillano and J. M. Forbes (Eds.), D. Reidel, Boston, xvii + 858 pp., 1983, $155.

Statistical Methods in Geology for Field and Lab Decisions, R. F. Cheeney, George Allen & Unwin, Boston, xvi + 169 pp., 1983, $25.

Terrigenous Clastic Depositional Systems: Applications to Petroleum, Coal, and Uranium Exploration, W. E. Galloway and D. K. Hobday (Eds.), Springer-Verlag, New York, xv + 423 pp., 1983, $39.

The Thunderstorm in Human Affairs, E. Kessler (Ed.), University of Oklahoma Press, Norman, 1983, $24.95.

Topics in Ocean Physics, Proceedings of the International School of Physics "Enrico Fermi," Course 80, Italian Physical Society, A. R. Osborne and P. M. Rizzoli (Eds.), North-Holland, New York, xv + 550 pp., 1982, $100.75.

Classified

RATES PER LINE

POSITIONS AVAILABLE

The College of William and Mary-Physics Faculty Position.

Senior Research Associate in Astrophysics: Lunar and Planetary Laboratory, University of Arizona.

Texas A&M University/Geological Oceanography Positions.

Planetary Geologist/Brown University.

University of Iowa/Faculty Positions.

Seagoing Science Officer/Research Assistant.

University of Arizona/Postdoctoral Research Position in Planetary Atmospheres.

Faculty Positions/SUNY Stony Brook.

Oceanography/FSU.

Computer Programming and Research Support.

University of Colorado-Boulder—Tenure Track Position in Atmospheric Dynamics.

Geophysics/Oregon State University. Applications are invited for a 12-month, tenure track position for an Assistant or Associate Professor of Geophysics in the College of Oceanography to complement the present eight member Geophysics faculty. The applicant must have a Ph.D. or equivalent, a demonstrated ability to conduct independent research in theoretical or observational geophysics, and to obtain research funding. Applicants will be considered in most areas of solid earth geophysics. Duties include teaching graduate courses in geophysics, supervising graduate students, and developing a program of grant-funded research. Interested candidates should submit a resume, names of three references, and a brief statement of research plans by March 1, 1984, to: G. Ross Heath, Dean, College of Oceanography, Oregon State University, Corvallis, Oregon 97331.

Oregon State University, an affirmative action/equal opportunity employer, complies with section 540 of the Rehabilitation Act of 1973.

University of Arkansas/Tenure-Track Position—Structural Geology. Applications are invited for a tenure-track position in structural geology/tectonics, beginning August, 1984. The Ph.D. is required. Candidates who will strengthen our anticipated Ph.D. program with research interests in field-oriented studies of rock deformation, rock fabrics (or metamorphism), or the tectonics of active margins which would complement growing programs in geophysics, sedimentation, and petrology are encouraged to apply. The successful applicant will direct graduate research and maintain this program with outside funding as well as teach undergraduate and graduate courses in structural geology and tectonics, an occasional course in introductory geology, and provide some support for the Montana field camp. Rank and salary are open, depending upon experience and qualifications. Applicants should submit a resume and statement of teaching and research interests directly and arrange to have at least 3 letters of recommendation sent to Robert C. Morris, Department of Geology, University of Arkansas, Fayetteville, AR 72701. Phone 501-575-3355, Deadline for all material is March 31, 1984.

University of Arkansas is an equal-opportunity/affirmative action employer.

Seismologist/University of Leeds(UK). The Department of Earth Sciences is seeking a Postdoctoral Research Fellow for a two-year period starting April 1984 to help in the continuing study of the seismicity and structure of the Cameroon Volcanic Line. The successful candidate will be in charge of the installation and maintenance of a telemetered network (seven stations) and training Cameroon scientists, and will complete the gravity survey of the volcanic province. The project is in full collaboration with IRGM (Cameroon). Applicants should have a Ph.D.

University of Georgia/12-month tenure-track faculty appointment in the School of Forest Resources.

SUNY-Albany/Tenure-Track Position in Tectonics or Structural Geology.

Structural Geologist/Geophysicist: University of Wisconsin—Eau Claire.

Summer Assistantships/National Astronomy and Ionosphere Center.

University of Oklahoma/Electronics Instrumentation Specialist. The School of Geology and Geophysics is accepting applications for a full-time Electronics Instrumentation Specialist. Principal responsibilities will include maintenance, calibration and user instruction for a new, computer-automated Rigaku XRD-XRF system, and maintenance and repair of electronic components of other lab facilities in the School. Additional opportunities could include involvement in the University's electron microscopy lab (SEM and TEM), and the development of a Van de Graaf-PIXE analytical system in collaboration with O.U. physicists. Applicants should have a B.S. in Geology, Chemistry, or Electrical Engineering or equivalent in experience; salary is commensurate with qualifications. Send curriculum vitae and names and addresses of three professional references to:

Dr. David London
School of Geology & Geophysics
University of Oklahoma
Norman, Oklahoma 73019

Deadline for applications is March 15, 1984.

The University of Oklahoma is an affirmative action/equal opportunity employer.

Applied Geophysics/Bolling Green State University. The Department of Geology invites application for a tenure track, assistant professor position in Applied Geophysics to begin September 1984. Ph.D. required. The successful candidate will be expected to develop a research program in some aspect of Applied Geophysics and teach courses in Geophysics, Exploration Geophysics and in his or her specialty.

The Department has eleven fulltime faculties. In addition, two faculties from the Physics Department participate in our geophysics program. Complete geophysical instrumentation, including a seismograph station and rock mechanics lab, is available.

Interested persons should send resume, statement of research interests, official transcripts, and three letters of reference to: Charles M. Onasch, Chairman, Search Committee, Department of Geology, Bolling Green State University, Bolling Green, OH 43403.

The closing date is March 15, 1984.

BGSU is an equal opportunity/affirmative action employer.

University of Washington/Geophysics—Research Faculty Positions. Applications are invited for two or three openings for research faculty. Individuals are to establish innovative and high-quality research programs and to obtain funding to maintain those programs (including salaries). Candidates with interests in the following subfields are particularly encouraged to apply: seismologists with experience and interests in volcanic earthquakes and associated phenomena and glaciologists with experience in ice cap flow modeling or in avalanche mechanics. Send

Research in Space Plasmas, Solar and Heliospheric Physics.

Water Resources Engineer/Hydrologist Faculty Position.

Staff Scientist/JPL.

Microprobe Technician-Operator/University of Maine at Orono.

Center for Ocean-Land-Atmosphere Interactions: Department of Meteorology, University of Maryland, College Park, MD The Department of Meteorology at the University of Maryland has established a center to study the interactions of ocean, atmosphee, and land processes and their impact on climate variability, and in particular to study the feasibility of dynamical prediction of short-term climate fluctuations. Applications are invited from qualified scientists to join the center at its inception. The center has the following openings:

1. *Assistant or Associate Professor:* One tenure track position for *Ocean Modelling*. The applicant should have good knowledge of oceanic and atmosphere dynamics, should also have the ability to develop ocean models and carry out research on variability and predictability of short term climate using coupled ocean-atmosphere models.

2. *Assistant or Associate Professor.* One tenure track position for *Atmospheric Predictability*. The applicant should have good knowledge of atmospheric dynamics and should have demonstrated his ability to carry out outstanding research on Geophysical Fluid Dynamics. Contributions to the study of atmospheric predictabiltiy either using simple models or complex GCMS, would be considered desirable.

3. *Research Scientist:* One non-tenure faculty position to be supported fully by the grant funds. The applicant should have demonstrated excellent knowledge of atmospheric dynamics and general cirulation of the atmosphere. Familiarity with the atmospheric GCMs is desirable but not essential.

4. *Assistant Research Scientist:* One non-tenure faculty position to be supported fully by the grant funds. The applicant should have demonstrated excellent knowledge of ground hydrology and interaction of vegetation and climate. Familiarity with application of land-surface process models in GCMs is desirable.

5. *Research Associate:* One position for one year with possibility of extension for the second year. The applicant should be a recent Ph.D. with interest in studying the dynamics of quasi-stationary atmospheric anomalies either by analysis of observed data or by analysis of model simulations.

6. *Faculty Research Assistants:* Three positions (two modelling and one for data analysis). The applicants should have at least M.S. in Meteorology and demonstrated their ability to work with large models and high speed computers. They should also have good understanding of synoptic and dynamic meteorology, and familiarity with modern techniques of processing large volumes of data.

Letters of application should be sent to:

J. Shukla, Chairman
Search Committee
Department of Meteorology
University of Maryland
College Park, MD 20742

Applications should include a curriculum vitae and names of three references. Applications received before March 15, 1984 will receive full con-

University of Hawaii/Marine Geophysics.

Atmospheric Scientist/University of Virginia.

Geophysics-Tectonophysics/University of Wyoming.

Structural Geologist/University of Maryland.

Marine Geologist or Physical Oceanographer: Eckerd College (Florida). Tenure track (Assistant Professor) faculty position to start September, 1984. Ph.D. required. Successful candidate will teach introductory and advanced courses in area of expertise. Applicants with interest in coastal processes and ability to contribute to College general education program will be favored. Establishment of an active research program is important. Send resume, transcripts, letter of application and three letters of reference before February 28, 1984 to:

Dr. John E. Reynolds, III
Eckerd College
P.O. Box 12560
St. Petersburg, FL 33733

Eckerd College is an equal opportunity employer.

Middlebury College/Sedimentary Geologist. The Department of Geology seeks a person with skills in sedimentary petrology, sedimentology, and/or stratigraphy, for a tenure track position. Appointment will be at the entry level and will begin September 1984. Letter of intent, resume, transcripts, and names of three referees should be sent, before March 1, 1984, to Brewster Baldwin, Chairman, De-

Geophysicist Position-University of Colorado, Boulder.

STUDENT OPPORTUNITIES

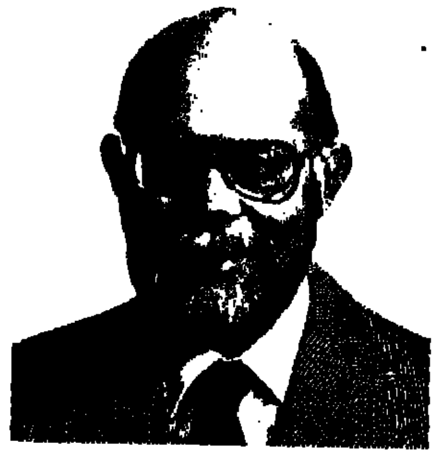
Graduate Research Assistantships in Geophysics/Michigan Technological University.

SERVICES, SUPPLIES, COURSES, AND ANNOUNCEMENTS

Scanning Electron Microscopy and X-ray Microanalysis/Lehigh University. June 11–15, 1984.

AGU

1983 Robert E. Horton Award



David A. Woolhiser

Citation

The recipient of this year's American Geophysical Union Robert E. Horton Award is David A. Woolhiser of the U.S. Department of Agriculture's Agricultural Research Service. Dr. Woolhiser is Supervisory Research Hydraulic Engineer and Research Leader for Watershed Hydrology at the Southwest Rangeland Watershed Research Center in Tucson, Arizona. His academic training was at the University of Wisconsin, where he received degrees of Bachelor of Science and Doctor of Philosophy, both in Civil Engineering, and at the University of Arizona, where he received an M.S. also in Civil Engineering.

Dr. Woolhiser's career has spanned government and academia and his contributions to hydrology have ranged from theoretical developments to practical applications.

He has more than 20 years of service with the U.S. Department of Agriculture and has been on the faculties of Cornell University, Colorado State University, and the University of Arizona. He is very active in the American Geophysical Union, the American Society of Civil Engineers, and the American Society of Agricultural Engineers.

Dave's first major contribution to scientific hydrology was an accurate solution to the shallow water equations with boundary conditions appropriate for overland flow. His derivation of a nondimensional kinematic flow number set forth a criterion for when the kinematic wave formulation can be used in place of the complete flow equations.

This initial contribution was extended in a number of important directions that led to the development of the kinematic overland flow model into an important hydrological tool. Dave collaborated in obtaining the first solutions to the combined overland flow and infiltration problem, utilizing a partial differential equation formulation for both phenomena. Additional developments include numerical methods to solve the kinematic wave equations, the formulation and solution of overland flow for converging surfaces, development of a kinematic cascade for surface runoff, and the formulation of a nonlinear kinematic wave model for overland flow.

Dave has also made important contributions in the application of the kinematic overland flow model to real-world problems.

A major outgrowth of Dave's overland flow research is a better understanding of the impact of spatial variability in catchment parameters on the outflow hydrograph and his pioneering work in nonpoint loadings.

The impact of Dave's contributions can be measured by the role kinematic modeling has in hydrology today. Virtually every graduate hydrology curriculum has a course in kinematic modeling. The U.S. Geological Survey's Distributed Routing Rainfall Runoff Model is based upon kinematic overland and channel flow equations and the U.S. Army Corps of Engineer's STORM model has a kinematic model component. The kinematic model is a widely accepted tool in hydrologic consulting.

Thus, it is with great pleasure that I present the 1983 AGU Robert E. Horton Award to Dr. David A. Woolhiser, a scientist and civil servant of the highest merit.

Peter S. Eagleson
President
AGU Hydrology Section

Acceptance

It is a great pleasure to receive this award. Upon reflecting on my research career in hydrology, it is clear to me that chance and privilege have played a major role leading to this occasion.

Because chance plays such an important part in hydrologic phenomena, it is, perhaps, appropriate that I entered the field by chance. In my undergraduate program at the University of Wisconsin, I concentrated on the structural option in the Agricultural Engineering Curriculum. I did take one course in hydrology, and wrote a B.S. thesis on a hydrologic topic, but I must admit that I really was not particularly excited about the subject. When graduation time came, however, my job offers were both for hydrologic research positions. I accepted a position as instructor with the Agricultural Engineering Department at the University of Arizona, and started work on July 1, 1955, installing raingages and surveying reservoirs at the Atterbury Reservoir Watershed east of Tucson, Arizona. During the course of the 3 years that I was associated with this project, I became fascinated with the challenges associated with describing surface runoff phenomena in semiarid regions. It became clear to me that distributed rainfall and runoff models were essential in this regard, and so my career goals were established.

I have been privileged in many ways. First, it has been my privilege to be active in hydrologic research at a time when developments in technology, especially computer technology, made it possible to carry out analyses and to propose models that simply were not feasible before. For example, the works by Lighthill and Whitham and Iwagaki on kinematic waves were published in 1955, and finite difference techniques were just beginning to be applied to problems in flood routing and hydraulics. My work on the kinematic wave was a natural extension of this and other work. In fact, had computers been available in 1937, Merrill Bernard probably would have developed a distributed model of surface runoff quite similar to those developed in the last decade.

Second, it has also been my privilege to work with a talented group of colleagues. Their contributions, directly or indirectly, cannot be properly acknowledged. However, I would like to name a few, while apologizing to the many left unmentioned. During my stay at Madison and Columbia, Missouri, Neal Minshall impressed upon me the importance of taking great care in collecting hydrologic data and the need to always check the instruments and the calculations. Jim Liggett, at Cornell University, suggested our collaboration in the finite difference solution of the shallow water equations, thus inaugurating a very exciting and productive period of research.

I found the environment at Colorado State University to be very stimulating. With people like V. M. Yevjevich, D. B. Simons, H. J. Morel-Seytoux, P. Todorovic, H. W. Shen, D. Dawdy, J. Salas, my ARS colleagues H. Duke, G. Kruse, and P. E. Smith, and an outstanding USGS group in the early days, as well as the many visiting faculty, there were many exciting ideas going around. My collaboration with Petar Todorovic in the stochastic description of daily precipitation and flood phenomena was particularly beneficial in that it gave me a better appreciation for what can be achieved by purely analytic methods as opposed to simulation techniques. As a full-time researcher with ARS, but with offices at the CSU Engineering Research Center, I probably had the best of both worlds—the benefit of daily contact with faculty and students without the daily demands of teaching and university committee activities.

Third, it has been my privilege to work with an outstanding group of graduate students. Working with them has been the most satisfying aspect of my career. Several have gone on to become prominent in hydrologic research or teaching, including Dave Kibler, Roger Smith, Vijay Singh, and Leonard Lane, to mention a few.

Finally, I would like to express my appreciation to my agency, the Agricultural Research Service of the U.S. Department of Agriculture. Although our research mission is an applied one, our managers recognize that practical applications are often hampered by theoretical problems, and that individual researchers require considerable freedom to choose areas of research.

To my colleagues, former students, the many aides and technicians who gathered experimental watershed data, and to the secretaries who typed barely legible papers, I would like to dedicate this award. This honor would not have been possible without you.

David A. Woolhiser

Meetings

Announcements

Magmatic Evolution

August 22–26, 1984 Field Conference on Open System Behavior in Magmatic Evolution: Petrological, Geochemical, and Geophysical Constraints, Taos, N. Mex. Sponsor, Institute for the Study of Earth and Man (ISEM). Information contact: Mike Dungan, Department of Geological Sciences, Southern Methodist University, Dallas, TX 75275; telephone 214-692-2750.

The conference will examine models of open system magmatism in the light of thermal, fluid dynamic, petrologic, geochemical, and isotopic considerations. Included on the schedule are afternoon field trips to volcanic areas near Taos, and morning and evening symposium sessions on such processes as magma mixing and crustal contamination in layered basaltic intrusions, batholiths, and volcanic rocks. Other topics will include physical and chemical constraints on the nature of magma chambers, mechanisms of magma migration, and general geochemical modeling techniques.

The application deadline for the conference is February 25, and extended abstracts are due May 1.

The Geophysical Year calendar last appeared in the December 6, 1983, issue.

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Aeronomy

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In another context, this technique can be used to intensively sample the precipitable water vapor in the atmosphere without using balloons. (Geometrical model, doppler data, tropospheric refraction, water vapor.)
J. Geophys. Res., Atmos., Paper 3D1948

Exploration Geophysics

0920 Magnetic and electrical methods
TRUE AND APPARENT SPECTRA OF BURIED POLARIZABLE TARGETS
D. Guptasarma (National Geophysical Research Institute, Uppal Road, Hyderabad 500 007, India)

If the chargeability of a buried target is not infinitesimal, the popularly used low chargeability approximation formulated by Seigel (1959) can produce large errors in the computation of apparent polarizability spectra. A more accurate alternative approximation, based on a complex, frequency dependent "dilution factor" is presented. It turns out that for dispersions of the minimum phase shift type this approximation can be somewhat simplified and that for targets with such a dispersion, buried in a nondispersive host rock, the apparent log-phase spectrum is only slightly different from a vertically shifted version of the true phase spectrum of the target.

These results should be useful for the computation of apparent polarizabilities in numerical modeling for IP, and in attempts for mineral discrimination through field measurements of phase spectra.
GEOPHYSICS, VOL. 49, NO. 2

Geochemistry

1410 Chemistry of the Atmosphere
DIURNAL AND LONGER-TERM TEMPORAL CHANGES IN THE COMPOSITION OF ATMOSPHERIC PARTICLES AT MAUNA LOA, HAWAII
Josef R. Parrington (Department of Chemistry, University of Maryland, College Park, MD 20742) and William H. Zoller

The collection of mid-tropospheric atmospheric particulate matter during upslope and downslope mountain winds was accomplished using two types of sector controllers between February 1979 and April, 1982 at Mauna Loa Observatory (MLO) on the island of Hawaii. Initially a simple time-of-day system was used for sampling. This was replaced in May 1980 by a digital system which monitors meteorological conditions, aerosol data, as well as time of day to differentiate between upslope and downslope winds. Particles derived from the marine environment were found to be much lower in concentration during downslope winds than upslope winds (15 ng/m^3, σ_g = 4.0 vs 270 ng/m^3, σ_g = 2.5). The mean ratio being 14 with simple time-of-day control and 21 with the improved and more discriminating digital sector controller. Crustal derived particles were 2.6 times lower in concentration in downslope winds. The presence of particles of Hawaiian basalt was determined [illegible] correction for this local crustal material, the upslope/downslope crustal dust ratio still remained high (2.2) and exhibited strong seasonal variations, being much lower between mid-February to July (1.2) when high concentrations of dust are transported from Asian deserts to Hawaii, than during the remainder of the year (3.2). Upslope sulfate concentrations averaged 1.7 times higher than downslope conditions at MLO (530 ng/m^3, σ_g = 1.9, vs 340 ng/m^3, σ_g = 2.0). (atmospheric composition, background aerosols, mountain winds, Hawaii)
J. Geophys. Res., Atmos., Paper 3D1852

1490 Instruments and Techniques (Infrared Reflectance)
RAPID DISCRIMINATION OF GRANITIC ROCK COMPOSITIONS BY LOW-RESOLUTION NEAR-INFRARED REFLECTANCE
Alex K. Baird (Geology Department, Pomona College, Claremont, California, 91711)

The slopes of near-infrared spectra between ~ 1 and ~ 2 μm from quartz-bearing plutonic rocks are strongly correlated with rock chemistry determined by X-ray spectrometry. The predictive equations derived empirically provide compositional data of adequate precision and resolution to discern patterns of regional geochemical variation in granitic batholithic rocks of southern California. As an analytical method, infrared spectrometry is rapid and inexpensive, and the method has potential in applications to direct field measurements and to data from aircraft and spacecraft scanner systems of relatively low spectral and spatial resolution, provided vegetative cover and surface alteration are not prohibitively masking. (Near-infrared, granitic rocks, rock discrimination).
J. Geophys. Res., B, Paper 3B1927

1499 General (Partition Coefficients)
PARTITION COEFFICIENTS OF Hf, Zr, AND REE BETWEEN PHENOCRYSTS AND GROUNDMASSES
H. FUJIMAKI (USGS, MS 963, BOX 25046, DFC, DENVER CO 80225), M. TATSUMOTO and K. AOKI

Partition coefficients of Hf, Zr, and REE between olivine, orthopyroxene, plagioclase, garnet, amphibole, ilmenite, phlogopite, and liquid have been determined. Samples consisted of megacrysts in kimberlite; phenocrysts in alkaline basalts, tholeiitic basalts, and andesitic to dacitic rocks; and synthetic garnet and clinopyroxene in a rock of Hawaiian tholeiite composition. The Hf and Zr partition coefficients between mafic phenocrysts and liquids are smaller than the Lu partition coefficients and are similar to the Nd or Sm partition coefficients. In particular, the Lu partition coefficient between garnet and liquid is much larger than the Hf partition coefficient. On the other hand, the Hf and Zr partition coefficients between ilmenite, phlogopite, and liquid are larger than the Lu partition coefficients for those minerals. Because ilmenite probably played an important role in forming the lunar high-Ti mare basalt sources, and garnet may be an important constituent in terrestrial magma sources, these data have an important bearing on petrogenetic tracer studies involving the Lu-Hf isotopic system as well as chronological studies. Hf-Zr elemental fractionation may not occur except during extreme fractionation involving Zr-minerals at extremely low oxygen fugacity. (Lu-Hf systematics)
J. Geophys. Res., Earth, Paper 3B5031

Geomagnetism and Paleomagnetism

2560 (Time variations, paleomagnetism)
MAGNETOSTRATIGRAPHY, PALEOMAGNETISM AND REMANENCE ACQUISITION IN THE TRIASSIC CHUGWATER FORMATION OF WYOMING
P.N. Shive (Department of Geology and Geophysics, University of Wyoming, Laramie, Wyoming 82071), M.B. Steiner and D.T. Huycke

The magnetic reversal sequence determined at five sections of the Chugwater Formation can be correlated over a distance of more than 200 km. A detailed study of 203 cores constituting a grid of samples taken from a normal to reverse transition zone at the Red Grade section shows that the transition is characterized by a fairly smooth 180° direction change accompanied by an intensity decrease in about 80 cm of section. The transition occurs in the same way in all vertical columns within the grid and in other columns at the same stratigraphic level up to 80 meters from the grid, and appears identical to the transition reported by Herrero-Bervera and Helsley at the same lithologic horizon about one km from the grid. Thermal and chemical demagnetization of grid samples removes a secondary remanence in the general direction of the earth's present magnetic field and does not reveal the presence of normal and reverse components in the same sample. The transition appears to have been magnetized during a reversal of the earth's field. Samples probably became magnetized in a few hundred years or less while they were close to the deposition surface. Paleomagnetic pole positions for all five sites are very closely clustered, and there appears to be no consistent long term polar wander from bottom to top in the sections. The mean pole position (46.6°N, 113.5°E; α_{95}=1.88°) agrees well with pole positions from previous studies of the Chugwater Formation. Taken together, these suggest the possibility of post-Triassic motion of the basement uplifts of Wyoming.
J. Geophys. Res., Earth, Paper 3B1795

Hydrology

3125 Glaciology
A MODIFIED THEORY OF BOTTOM CREVASSES USED AS A MEANS FOR MEASURING THE BUTTRESSING EFFECT OF ICE SHELVES ON INLAND ICE SHEETS
F. C. Jezek (Geophysical and Polar Research Center, University of Wisconsin, Madison, Wisconsin 53706).

Bottom crevasses are fractures that extend upwards into floating ice shelves. They form when sea water...

...an aquifer that is polluted by a constant contaminant source. They are: pumping for contaminant removal; water injection for in-ground dilution; and a pumping, treatment, and injection cycle. A transient model designs either contaminant plume interception or in-ground dilution so that water quality standards are met. The method is not limited to these cases. It is generally applicable to the optimization of many types of distributed parameter systems.
Water Resour. Res., Paper 3W1963

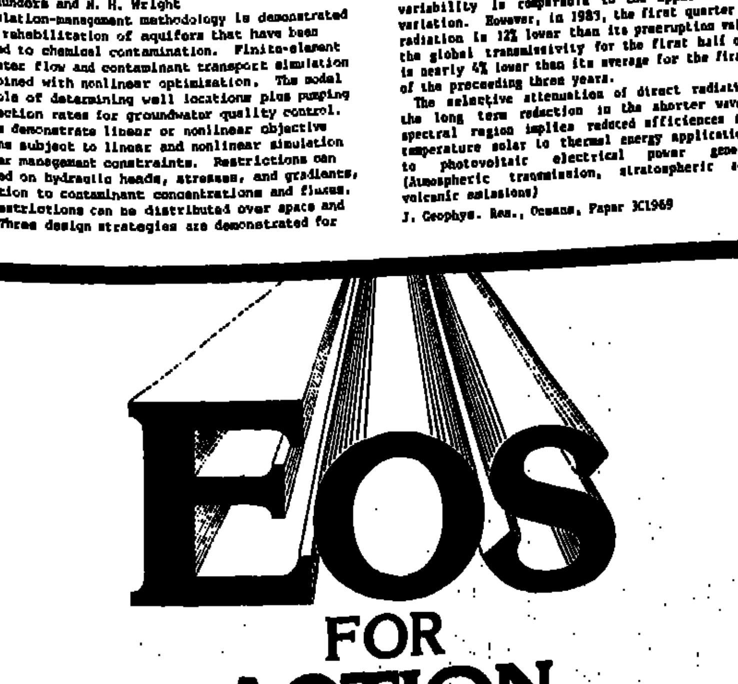
3150 (Precipitation)
OPTIMAL ESTIMATION OF THE AVERAGE AREAL RAINFALL AND OPTIMAL SELECTION OF RAIN-GAUGE LOCATIONS.
C. Bastin (Laboratoire d'Automatique, de Dynamique et d'Analyse des Systèmes, University of Louvain, B-1348 Louvain-la-Neuve, Belgium), B. Lorent, C. Duqué and M. Gevers.

A simple procedure for the real-time estimation of the average rainfall over a catchment area is described. The rainfall is modelled as a 2-dimensional random field (RF). The average areal rainfall is computed by a linear unbiased minimum variance estimation method (Kriging) which requires the knowledge of the variogram of the random field. A time-varying estimator for the variogram which takes into account the influences of both the seasonal variations and the rainfall intensity is proposed. The average areal rainfall estimator has been implemented in practice. Its application to real data in two river basins in Belgium is presented. Finally, it is shown how the method can be used for the optimal selection of the rain-gauge locations in a basin.
Water Resour. Res., Paper 3W1935

3175 Soil moisture
A GEOSTATISTICAL APPROACH TO THE TRICKLE IRRIGATION DESIGN IN HETEROGENEOUS SOIL: II A FIELD TEST
David Russo (Division of Soil Physics, Agricultural Research Organization, The Volcani Center, Bet Dagan, Israel.

In a heterogeneous field in which the soil properties vary, under a 'deterministic' uniform trickle irrigation system, the midway soil-water pressure head (h_c), and the yield (Y) of a crop also differ from place to place. These differences may, in turn, reduce the average (over the field) yield, relative to the yield that would be obtained if the soil was uniform throughout the field. A field experiment was conducted to test the hypothesis that this yield reduction may be eliminated by using a spatially variable trickle irrigation system. Twenty-five plots of Bell pepper (Capsicum frutescens var. 'Maor') were established on a 30-m square grid. Half of each plot was equipped with trickle irrigation system with constant spacing between emitters of d=50 cm, and the other half was equipped with trickle irrigation system for which the spacing between the emitters was selected using the pertinent hydraulic properties as described in Part I. It was found that the use of a spatially variable d relative to the use of a uniform d reduced the spatial variability in h_c and Y by 35% and 11%, respectively, increased the integral scale of h_c and Y by 30% and 10%, respectively, but increased the average fruit yield by only 1.9%. The use of a spatially variable...

Meteorology



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Oceanography